

**ENVIRONMENTAL MONITORING OF FORESTRY
CONTROL OPERATIONS
(EMOFÇO)**

1989 REPORT

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1990



ABSTRACT

This multi-disciplinary compilation reports on the operational, research and regulatory aspects of the forest insecticide and forest herbicide spray programs, primarily in New Brunswick. The pesticides investigated are:

- insecticides - fenitrothion, and Bacillus thuringiensis (various formulations); and
- herbicides - glyphosate, and hexazinone.



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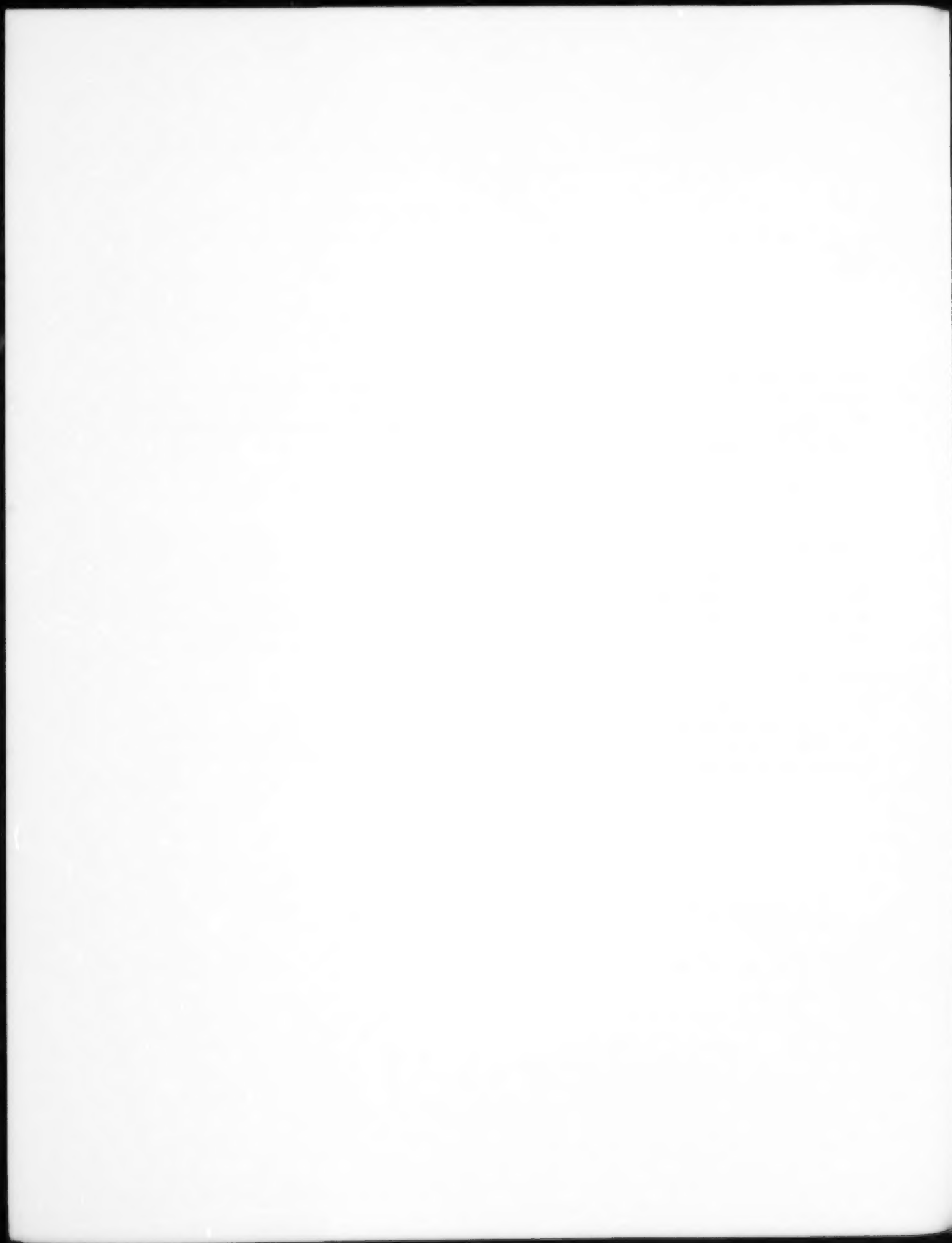
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FOREWORD

The New Brunswick Committee for Environmental Monitoring of Forestry Control Operations (EMOFCO), formerly the New Brunswick Committee for Environmental Monitoring of Forest Insect Control Operations), is an informal association of biologists, foresters, environmental specialists and chemists from federal and provincial governments, industry and universities. The Committee assumed its name and structure in 1976 and has been under the aegis of the Department of the Environment since 1980.

Its prime objective is to exchange information on forestry spray programs and on their impact on the environment. In the recent past, this has included both herbicide and insecticide spray programs. The potential consequences of forest spray programs for human health are beyond the Committee's terms of reference. Although the Committee's focus is on spray activities in New Brunswick, it seeks to be aware of forestry control operations and related environmental studies in the Atlantic region as well as in Maine and Quebec.

The 1989 report is aimed at broad readership - scientists, regulators, resource managers, and the public. It consists of preliminary reports and abstracts of reports compiled. The present dearth of research pertaining to environmental monitoring of forestry spray operations in New Brunswick is reflected in the format and content of this report, although the focus of the committee has not changed.



INSECTICIDES

Operational

1989 New Brunswick Protection Program Against Spruce Budworm

N. Carter

Spruce Budworm Conditions in 1989

The 1989 aerial survey for defoliation was conducted in the standard manner and revealed an estimated 67 000 ha of light, 129 000 ha of moderate, and 267 000 ha of severe defoliation (Figure 1). Approximately 75.8% of the M-S defoliation was outside the treated areas. Defoliation was detected in largest concentrations throughout the north-central and northern parts of the Province, primarily in Restigouche and Northumberland Counties. Except for occasional small areas of defoliation, the majority of the rest of the Province was undamaged. The 396 000 ha of M-S defoliation is 20% less than in 1988, and is 80% below the 2.03 million ha in 1983.

1989 Spray Program

The 1989 Spruce Budworm Spray Program (Figure 2) conducted by Forest Protection Limited, in New Brunswick covered approximately 576 000 hectares. This is 28.6% more than the 448 500 ha treated in 1988. Another 34 000 ha were sprayed by J. D. Irving Ltd. on its own freehold limits (compared to 98 000 ha in 1988).

Of the total area treated by FPL, 80.9% received a double application of the chemical fenitrothion (Sumithion) and 0.9% received a single application as the second was deemed unnecessary by larval counts after the first application. About 18.2% of the area received a single (7.0%) or double (11.2%) treatment of bacterial insecticide, Bacillus thuringiensis var. kurstaki (B.t.) in the form of two products, viz. Futura XLV and Dipel 176 (Table 1).

Spray aircraft included 12 TBMs, 2 four-engine DC-6s, and 11 single-engine agricultural-type small spray planes (SSPs). TBMs were used to treat 47.6% of the total area and the DC-6 treated 39.2% of the area. B.t. was applied undiluted at the normal 30 BIU/ha rate in one or two applications by TBMs, and once or twice at 15 BIU/ha using SSPs with enhanced atomization (i.e. Micronair AU4000s with reduced flow rates/unit). Fenitrothion was applied in water-based formulation at the normal 210 g/1.47 L/ha rate from TBMs and DC-6s, and

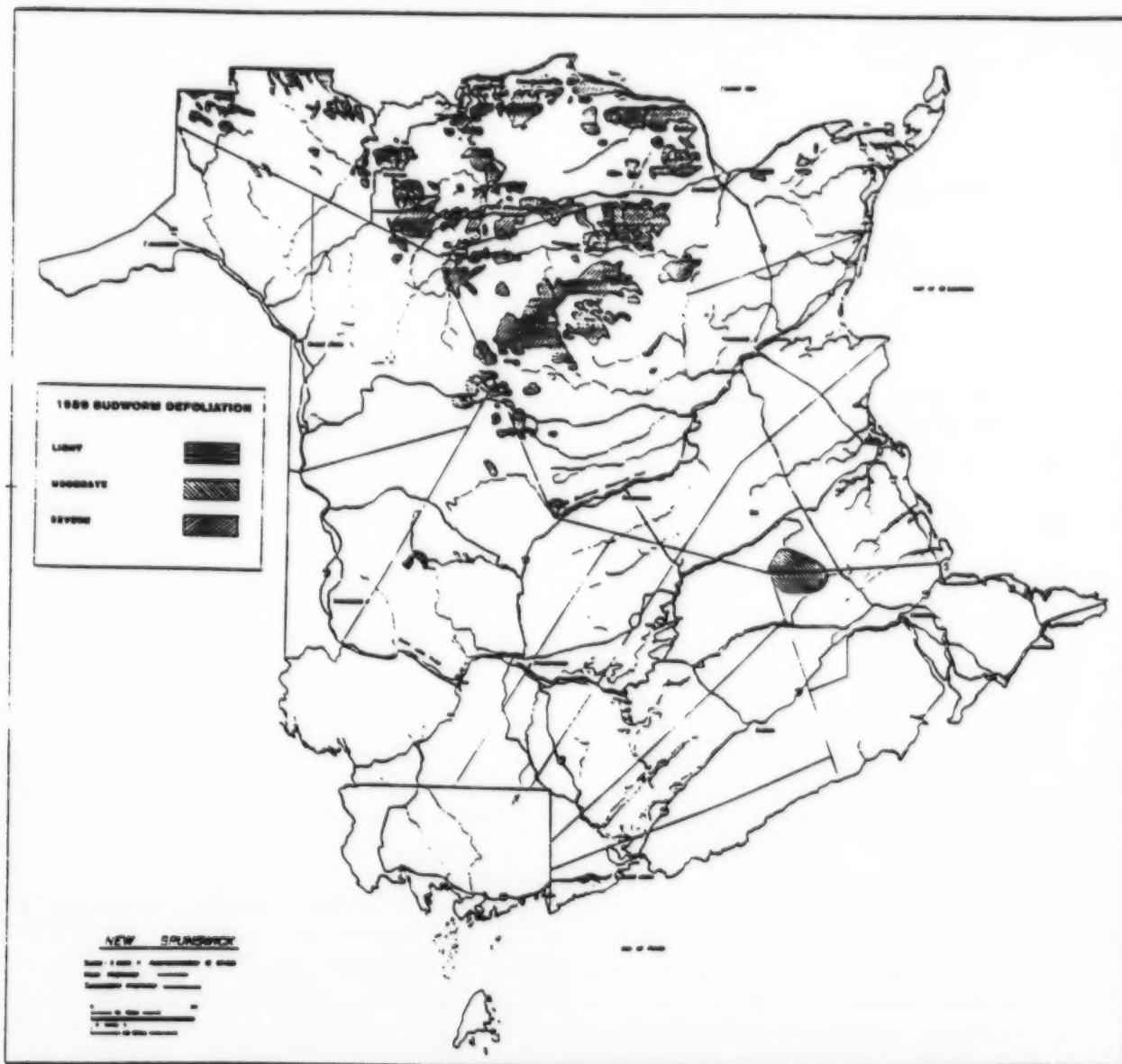


Figure 1. Areas of light, moderate and severe defoliation caused by spruce budworm in New Brunswick in 1989.



Table 1. Areas sprayed by Forest Protection Limited for spruce budworm control in 1989 in New Brunswick*. (Does not include J.D. Irving Ltd. program).

Treatment**	Hectares (Thousands)	Percent	Aircraft Type
One Application - Biological			
15 BIU-D176/1.18 L/ha	8.8	(1.5)	SSP
30 BIU-FXLV/1.01 L/ha	12.0	(2.1)	SSP
30 BIU-FXLV/2.02 L/ha	10.2	(1.8)	TEM
30 BIU-D176/2.36 L/ha	9.0	(1.6)	TEM
SUB-TOTAL	40.0	(7.0)	
Two Applications - Biological			
15 BIU-D176/1.18 L/ha + 15 BIU-D176/1.18 L/ha	18.3	(3.2)	SSP
15 BIU-D176/1.18 L/ha + 15 BIU-FXLV/1.01 L/ha	31.6	(5.4)	SSP
30 BIU-FXLV/2.02 L/ha + 30 BIU-FXLV/2.02 L/ha	4.7	(0.8)	TEM
30 BIU-D176/2.36 L/ha + 30 BIU-FXLV/2.02 L/ha	10.3	(1.8)	TEM
SUB-TOTAL	64.9	(11.2)	
SUB-TOTAL BIOLOGICAL	104.9	(18.2)	
One Application - Chemical			
210 g Fen/0.44 L/ha	5.3	(0.9)	SSP
Two Applications - Chemical			
210 g Fen/1.46 L/ha + 210 g Fen/1.46 L/ha	466.7	(80.9)	TEM, DC-6
SUB-TOTAL CHEMICAL	472.0	(81.8)	
GRAND TOTAL	576.9	(100.0)	

*Source: Forest Protection Ltd.

**D176 = Dipel 176
 FXLV = Futura XLV
 Fen = Fenitrothion

at 210 g/0.44 L/ha from SSPs.

The first spray blocks were declared biologically ready for chemical spraying the evening of May 26th and spray operations commenced the morning of May 28th after a few days of unacceptable spray weather. The first B.t. blocks were declared biologically ready on the evening of May 30th and spraying began the next evening. The operational program was completed on the evening of June 17th. Weather during the spray period was regarded to be "normal", although 7 days of the 22-day period were unacceptable for spraying.

Results of Spray Program

This year spring populations of spruce budworm larvae were generally lower (Figure 3) and the intensity of feeding damage was less than in 1988 (Figure 4). Weather conditions were warmer during this year's spray season due primarily to higher minimum temperatures. Though total rainfall was greater during this year's spray period, rain did not occur on as many consecutive days as last year. Shoot elongation and larval development were also more advanced this year at the time the blocks were deemed ready for treatment.

Compared to 1988, the 1989 spray program contained a greater proportion of area treated with Fenitrothion than B.t. (i.e. 80/20 vs 50/50). Less moderate and severe defoliation was found in treated areas this year compared to last (i.e. 16% vs 38%). In 1988, each total treatment area had about the same proportion of moderate and severe defoliation (i.e. Fenitrothion = 16.4% vs B.t. = 17.6%). Whereas the value for Fenitrothion is similar to 1988 (i.e. 19%), the value for B.t. is greatly improved from the last year's value of 60%. The average for spray programs based mostly on chemicals in the last 13 years is 16% (range 6% to 38%).

Table 2 provides summary data from sample plots in each treatment. When B.t. data were pooled and compared to the pooled Fenitrothion data there were no differences in the overall levels of protection afforded (Figure 5). Mean pre-spray populations in B.t. areas were lower than in Fenitrothion areas (e.g. mean B.t. = 9.4 larvae/branch and 0.104 larvae/bud vs. mean Fenitrothion = 16.2 larvae/branch and 0.186 larvae/bud).

The SSP 2 x 15 BIU/ha treatment gave the best B.t. results followed by the TBM 1 x 30 BIU/ha (Figures 6 and 7). There were few observations above the moderate range for SSP 1 x 15 BIU/ha but results were positive in the low range. Ironically the TBM 2 x 30 BIU/ha did not provide as good protection as the other B.t. rates. It is not known whether higher populations, later application (due to operational queuing), or insufficient deposit (not measured) might account for this.

In Fenitrothion plots treated by TBMs, mean defoliation was generally lower than in DC-6 plots across the population ranges examined (Figures 6 and 7).

Overall, Fenitrothion results this year were on par with traditional expectations. For B.t., the results of 1989 were a qualified success contrasting the qualified failure of 1988. In other words, this year's operation was successful, but did not yield sufficient data on which to

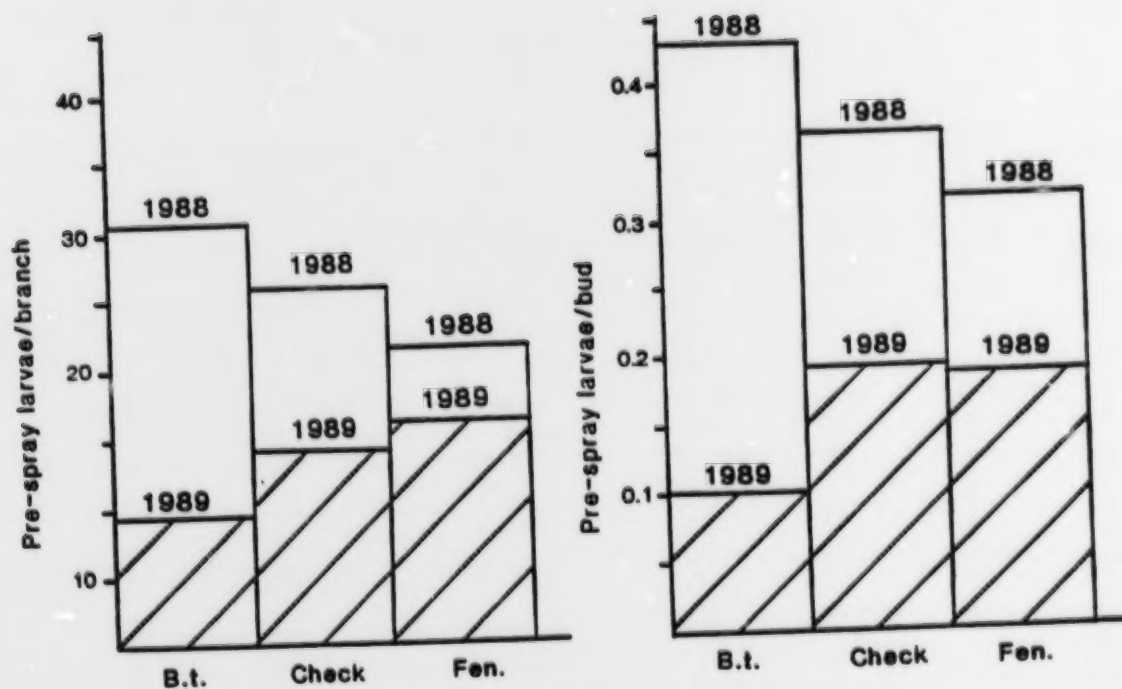


Figure 3. Mean pre-spray larval densities (larvae/branch or larvae/bud) in check plots, combined Fenitrothion, and combined B.t. treatment plots, in 1989 compared to 1988.

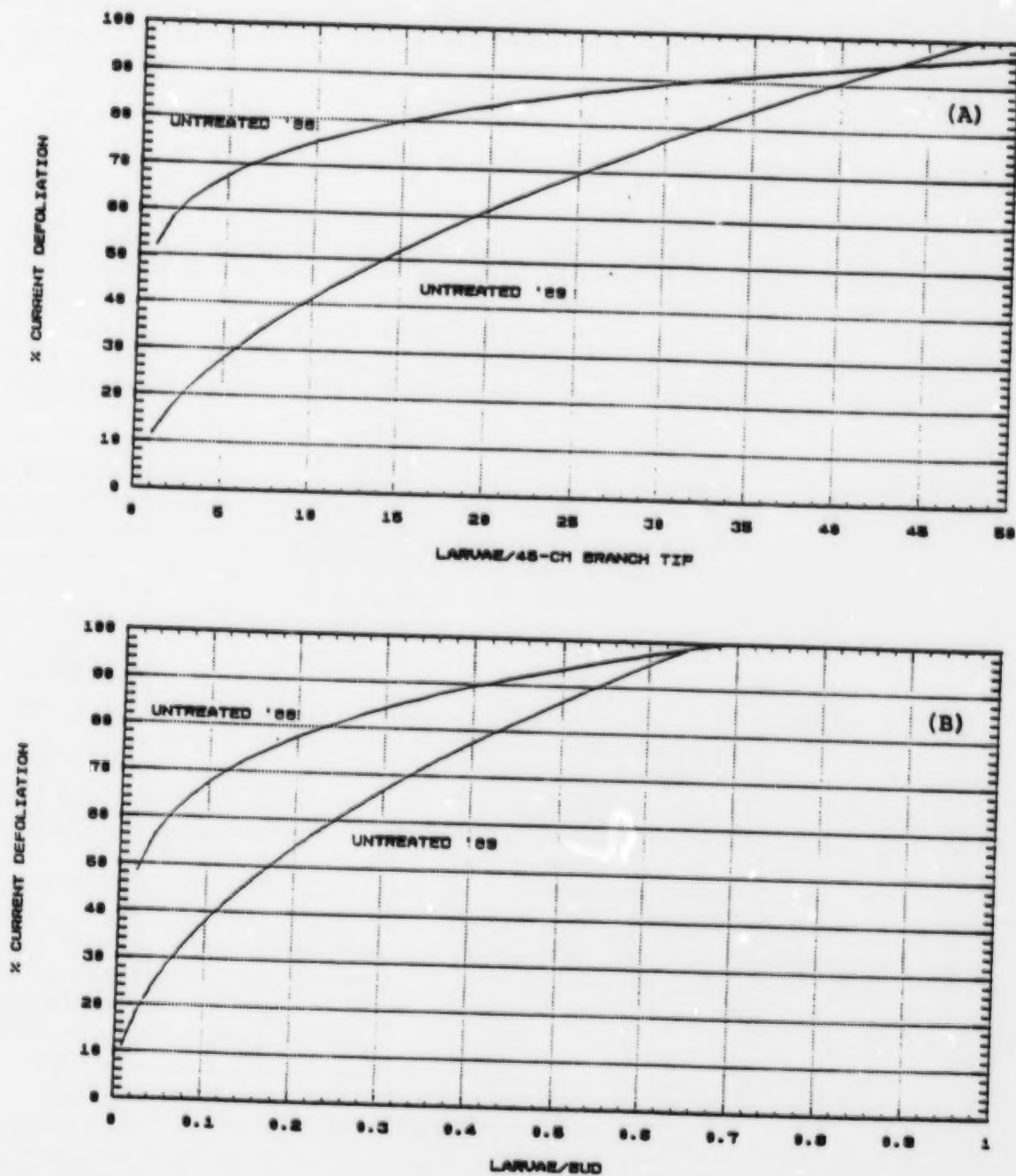


Figure 4. Comparison of relationships between expected defoliation and larvae/branch (A) or larvae/bud (B) from untreated check plots in 1988 and 1989.

Table 2. Summary data for treatments applied in 1989.

Block	Lines	Aircraft	n	Pre-Spray Larvae		% Mortality		Defoliation	
				Per 45-cm	Per Bud	Obs.	Corr. ^a	Obs. %	% Red
<u>Kedgwick</u>									
<u>Fenitrothion - 2 X 210 g/ha</u>									
A-1	3-28	TEM	50	15.9	0.125	89.0	66.0	18.7	67.2
A-3 (A)	3-20	TEM	50	10.8	0.152	97.7	91.5	15.9	68.1
A-3 (B)	24-80	TEM	75	18.6	0.306	96.4	85.7	30.4	57.8
A-4	50-110	TEM	75	16.0	0.184	98.4	90.7	16.0	71.9
A-9	4-30	TEM	75(92) ^b	17.8	(0.185)	95.6	84.7	(12.6)	(76.0)
A-19	21-54	TEM	30	7.6	0.107	82.2	60.4	9.8	79.6
<u>Bacillus thuringiensis - 1 X 15 BIU/ha</u>									
A-6 (B)	156-168	SSP	50	7.1	0.074	94.9	81.9	9.6	72.8
A-10	0-17	SSP	50	9.8	0.084	94.4	87.8	18.0	64.9
<u>Bacillus thuringiensis - 2 X 15 BIU/ha</u>									
A-7	14-24	SSP	50	6.0	0.068	97.6	91.2	2.9	86.0
A-6 (A)	121-149	SSP	50	7.3	0.099	92.6	78.7	5.2	81.6
A-11(B)	2-0	SSP	50	9.8	0.082	100.0	100.0	10.2	69.0
<u>Bacillus thuringiensis - 1 X 30 BIU/ha</u>									
A-11 (A)	19-27	TEM	50	6.5	0.069	99.6	92.7	7.0	80.8
<u>Bacillus thuringiensis - 2 X 30 BIU/ha</u>									
A-8	36-47	TEM	50 (70)	17.6	(0.208)	91.3	79.1	(29.9)	(48.4)
<u>Untreated</u>									
C-502	-	-	50	6.8	0.073	82.5	-	19.8	-
C-104 (C)	-	-	50	10.1	0.185	73.1	-	48.1	-
C-508 (D)	-	-	68	24.2	0.363	80.3	-	87.4	-
C-105 (E)	-	-	50	12.3	0.156	83.6	-	25.4	-
<u>Campbellton</u>									
<u>Fenitrothion - 2 X 210 g/ha</u>									
D1 (A)	0-35	DC6	75	14.8	0.174	89.7	74.4	24.8	55.3
D1 (B)	50-102	DC6	75	12.1	0.118	99.2	95.6	7.1	79.4
D1 (C)	44-64	DC6	50	10.7	0.155	94.6	83.3	14.8	69.2
D1 (D)	85-120	DC6	50	21.4	0.264	95.4	78.3	19.2	66.2

^a based on curve of % natural mortality vs. larvae/45-cm branch tip.^b extra samples with larvae/bud and defoliation data.

Table 2. Con't.

Block	Lines	Aircraft	n	Pre-Spray Larvae		% Mortality		Defoliation	
				Per 45-cm	Per Bud	Obs.	Corr. ^a	Obs. %	% Red
<u>Bacillus thuringiensis</u> - 1 X 30 BIU/ha									
A-12	0-11	TEM	50	10.9	0.105	80.5	51.0	14.9	57.8
<u>Untreated</u>									
C-101 (A)	-	-	50	7.1	0.087	74.2	-	25.9	-
<u>Bathurst</u>									
<u>Fenitrothion</u> - 2 X 210 g/ha									
D1 (A)	151-159	DC6	20	33.9	0.372	87.1	41.6	76.2	13.7
D1 (B)	94-150	DC6	50	23.9	0.223	98.5	89.3	34.9	44.5
D1 (C)	135-149	DC6	20	23.0	0.231	82.5	51.7	48.7	22.9
A-16	158-164	TEM	15	11.0	0.114	95.7	82.6	45.8	22.4
<u>Untreated</u>									
C-17	-	-	15	39.3	0.507	83.7	-	99.3	-
C-102	-	-	50	12.1	0.200	56.5	-	57.9	-
<u>Newcastle</u>									
<u>Fenitrothion</u> - 2 X 210 g/ha									
A-21	0-15	TEM	25	4.8	0.070	98.9	84.7	2.3	88.6
A-24	3-22	TEM	15	22.4	0.130	92.4	45.2	34.1	45.9
<u>Untreated</u>									
C-220	-	-	25	26.0	0.167	68.2	-	54.2	-
C-221	-	-	25	9.6	0.103	69.6	-	23.2	-
<u>Frederickton</u>									
<u>Fenitrothion</u> - 2 X 210 g/ha									
A-25	6-15	TEM	30	19.8	0.198	89.3	56.6	23.9	52.9
<u>Untreated</u>									
C-225	-	-	30	16.5	0.177	68.2	-	54.5	-

^a based on curve of % natural mortality vs. larvae/45-cm branch tip.

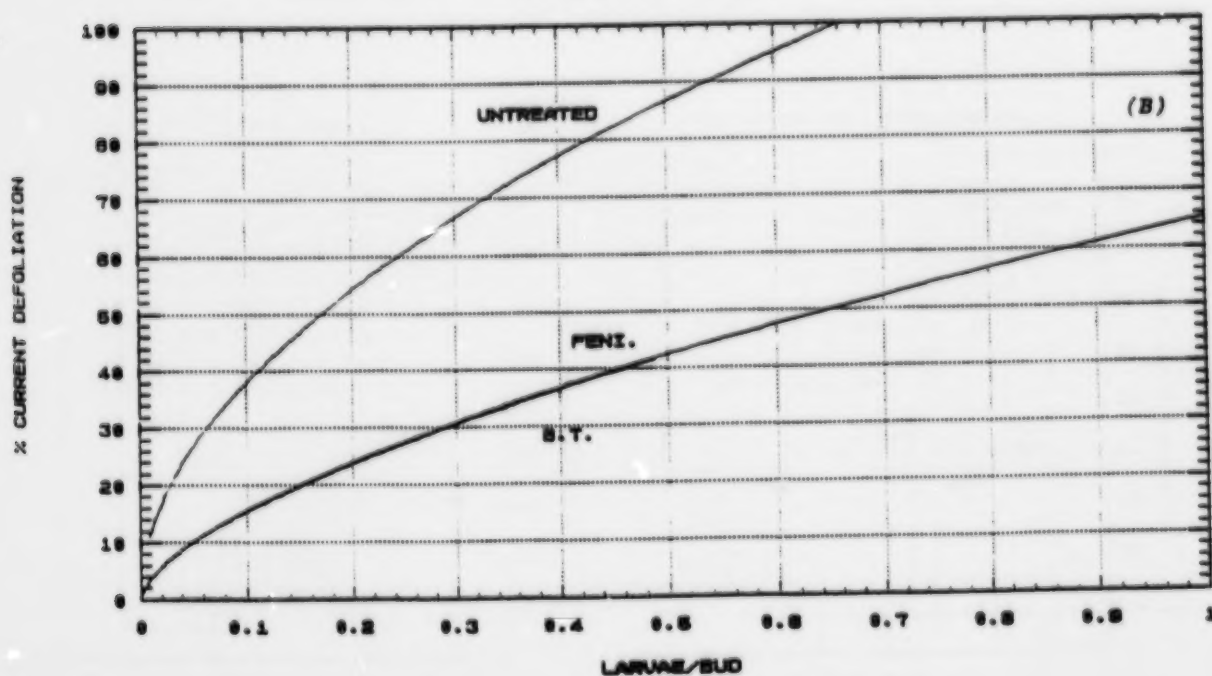
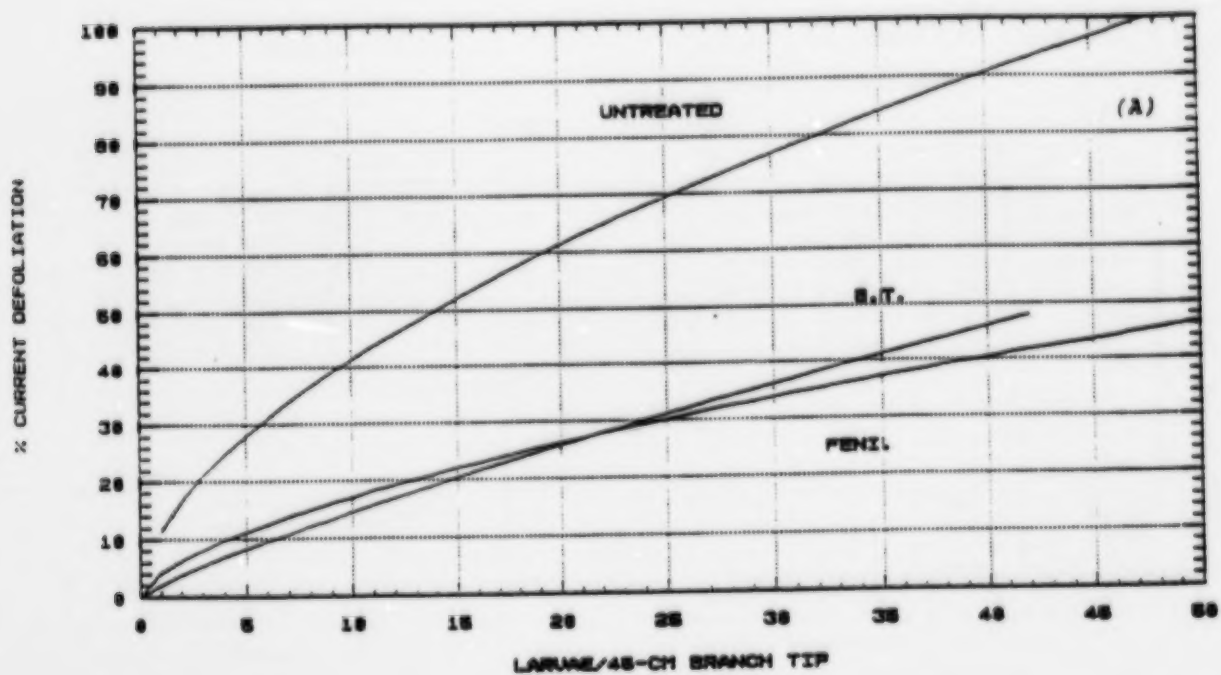


Figure 5. Relationships between defoliation and larvae/branch (A) or larvae/bud (B) from pooled Fenitrothion, pooled B.t., and untreated plots in 1989.

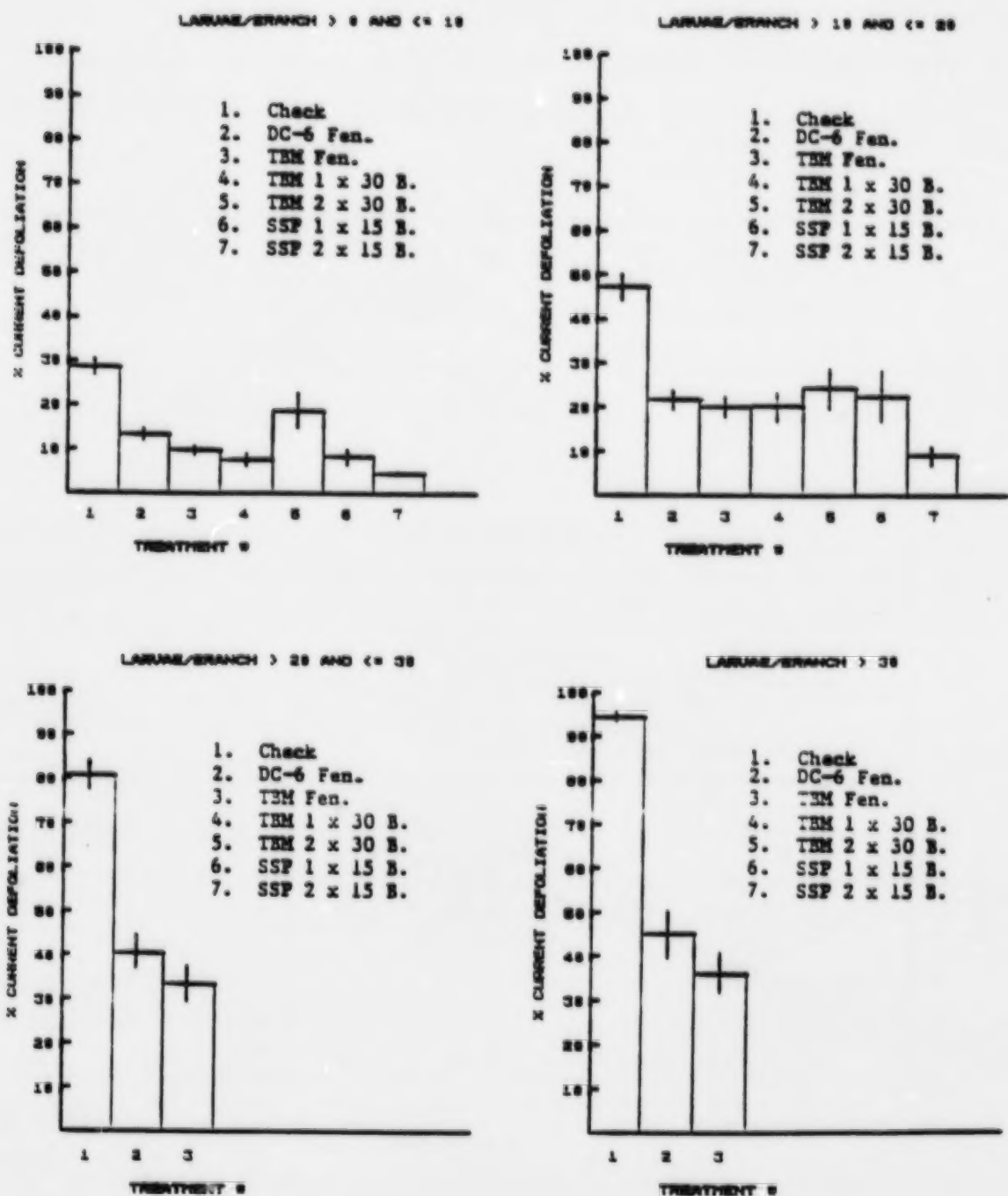


Figure 6. Mean percent defoliation for each treatment in various lar-
vae/branch population ranges in 1989.

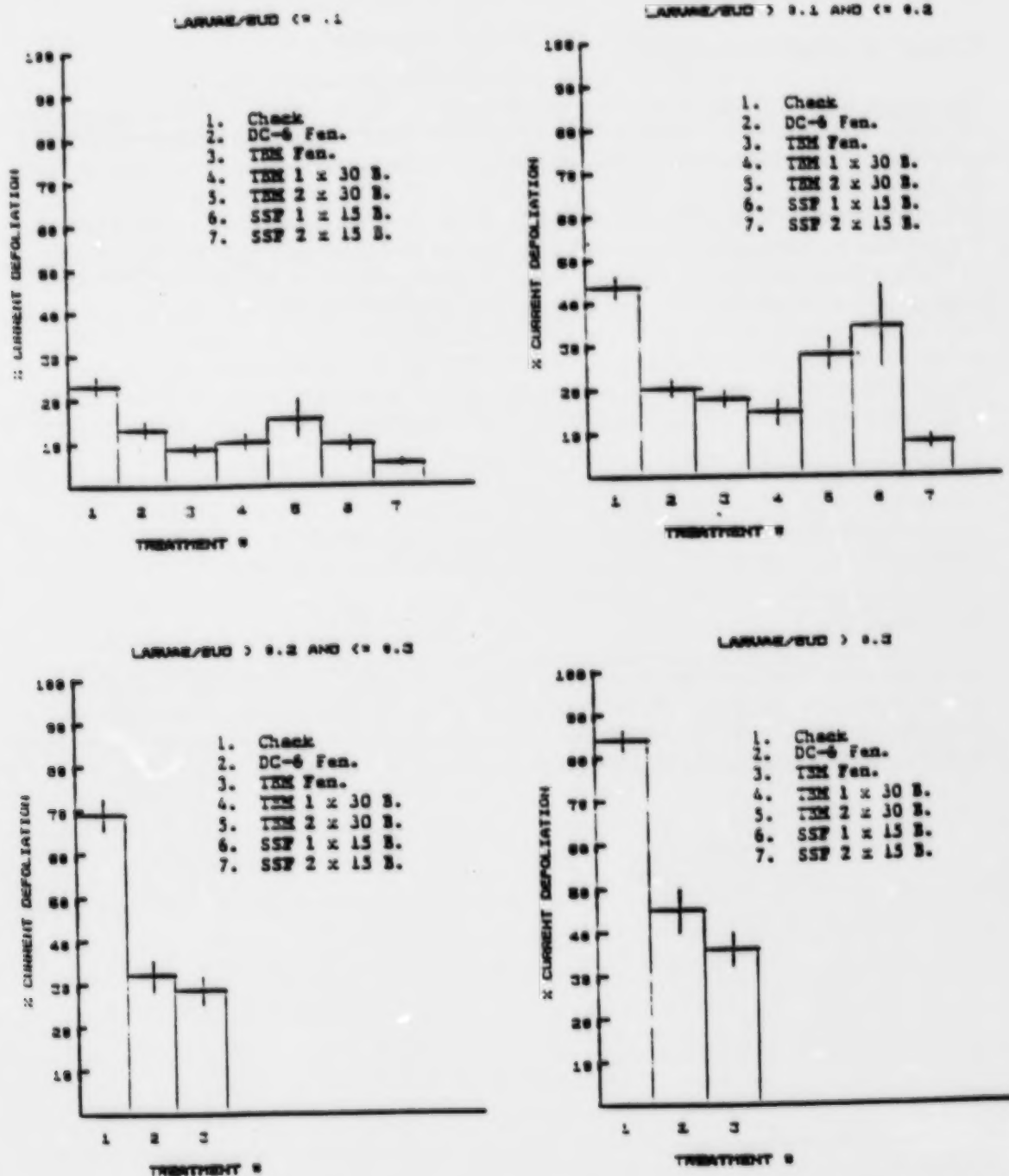


Figure 7. Mean percent defoliation for each treatment in various larvae/bud population ranges in 1989.

evaluate the performance of B.t. under high population conditions. Present thinking suggests that in 1989, larval populations, shoot development, and weather were more conducive to successful B.t. use than 1988.

Forecast of Infestation for 1990

The spruce budworm egg mass survey was replaced by the L2 survey in 1985 as the method of forecasting infestation levels in New Brunswick. Table 3 compares the proportion of sample points within each infestation category used in the initial forecasts from 1981 to 1989. Between 1982 and 1986 there was an increasing trend in the percent of points in the Low category with a corresponding decreasing trend for the High category. In 1987, there was a three-fold increase in the proportion of points in the High category in the North-central to North-western parts of the Province, primarily Restigouche County. Most of Restigouche County now contains variable low to moderate populations, whereas moderate to high populations occur in the northwestern part of Northumberland County and adjacent western part of Gloucester County. Except for one large area of variable populations in the west-central area, and one moderate to high pocket northwest of Moncton no significant damage is expected throughout the majority (80%) of the Province.

The forecast for 1990 is for 1.47 million ha (Figure 8) of variable (low to moderate) and moderate to high infestation, which is a 10% decrease from last year's forecast (Table 4). Of most significance is the 65% decrease in the area with moderate to high population levels compared to last year (i.e. 0.5 million ha compared to 1.5 million ha).

Plans for 1990

Spray plans for 1990 have not been formulated at this time. Nevertheless, it does appear that a protection program will be required in New Brunswick next year. Whether a combination of chemical insecticides and B.t. will again be used is presently not known. Tentative spray plans should be known by mid-December.

Table 3. Comparison of Spruce Budworm Forecast Infestation Levels 1981-1989.

YEAR/SURVEY	FORECAST INFESTATION LEVEL			LOCATIONS ^a
	LOW	MODERATE	HIGH	
1981/egg-mass	591 (34%)	441 (25%)	708 (41%)	1740
1982/egg-mass	458 (26%)	512 (29%)	783 (45%)	1753
1983/egg-mass	636 (48%)	257 (20%)	423 (32%)	1316
1984/egg-mass	747 (51%)	331 (22%)	398 (27%)	1476
1985/L2	833 (56%)	503 (32%)	185 (12%)	1521
1986/L2	1216 (77%)	322 (20%)	48 (3%)	1586
1987/L2	1198 (76%)	230 (15%)	144 (9%)	1572
1988/L2	879 (73%)	226 (19%)	99 (8%)	1204 ^b
1989/L2	1102 (82%)	180 (13%)	67 (5%)	1349 ^b

a - Supplementary sampling not included.

b - Fewer samples taken because of collapse in southern part of province.

Table 4. Comparison of forecast area (ha) of Moderate and High infestations 1982-1989, including Variable (low-moderate) infestations in 1988 and 1989.

YEAR (N)	(N + 1) FORECAST
1982	5.30 million ha
1983	4.10 million ha
1984	3.57 million ha
1985	3.15 million ha
1986	1.71 million ha
1987	1.50 million ha
1988	1.65 million ha
1989	1.47 million ha

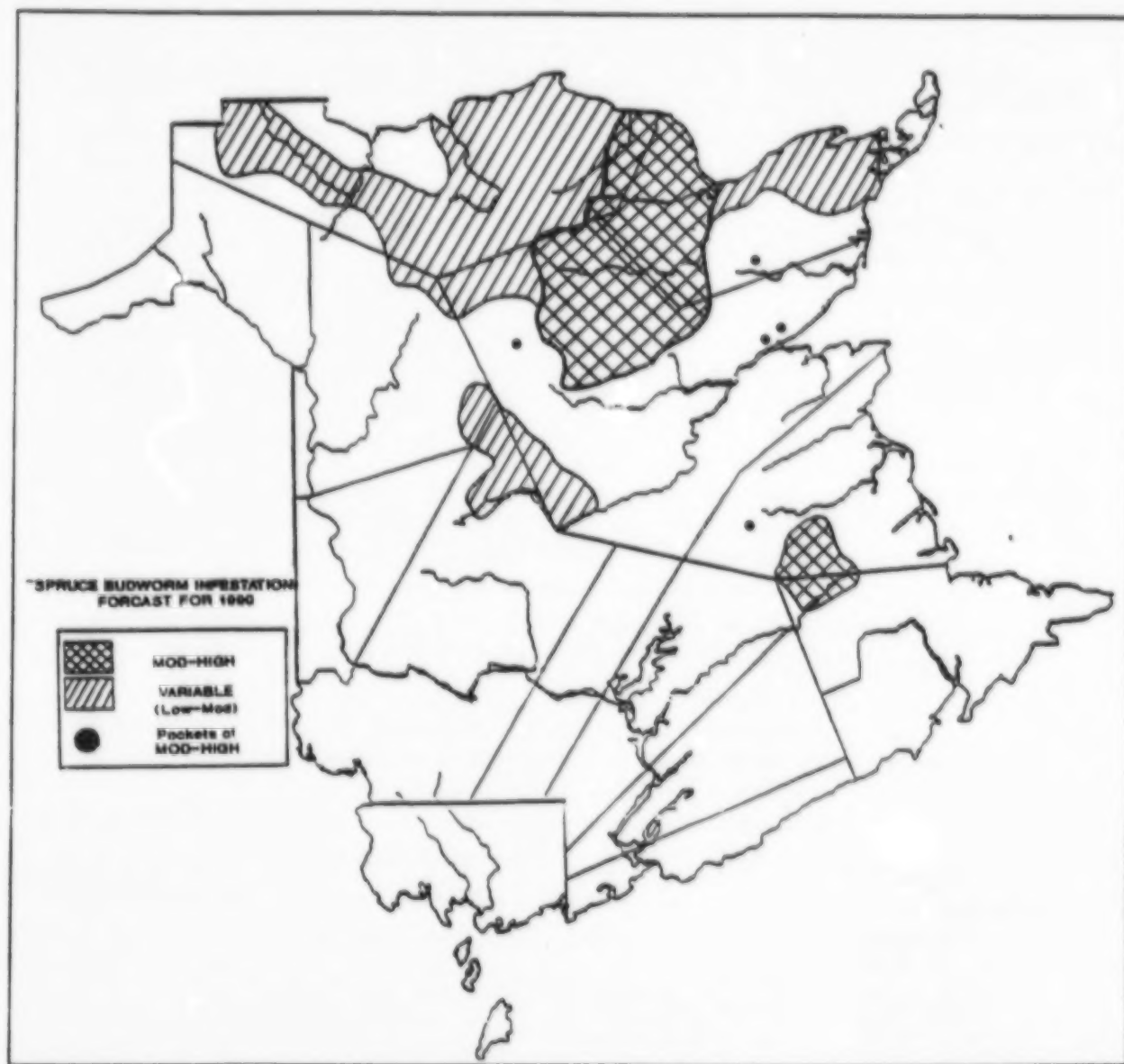


Figure 8. Areas of New Brunswick forecast to have variable (low to moderate), and moderate to high spruce budworm populations in 1990 based on the 1989 L2 survey.

Research

Review of Pest Management Research & Development In New Brunswick in 1989

E. G. Kettela

INTRODUCTION

This summary covers work conducted under the supervision of Forestry Canada-Maritimes and includes results of B.t. testing against the spruce budworm, pheromones for control of Zeiraphera and laboratory trials with exotic parasites. Funding agencies included Forest Protection Ltd., Chemagro Ltd., C.I.L., Abbott Laboratories and the NB/Canada Forestry Development Agreement.

Development of B.t. Products and Tactics Product Development:

Development trials were carried out with the following new products CIL-E 2492, Dipel 16L(352) and 96 AF. The results of these trials show acceptable efficacy when compared to a positive control block treated with FUTURA XLV (Table 1) Fig. 1). The results with Dipel 16L(352) at 30 and 15 BIU/ha were similar and support the enhanced atomization reduced dosage concept of B.t. application. Trials with FUTURA "O" were cancelled because the formulation became so viscous it was impossible to pump. CIL-E 2492 is now registered and sold under the trade name of Biodart.

B.T. Optimum use/weather impact trials:

The multi-agency B.t. optimum use/weather impact trials with FUTURA XLV-HP, were conducted as planned. The following executive summary details the salient points of this R & D program.

EXECUTIVE SUMMARY

"Optimum Use of B.t."

Purpose of the trials:

These trials were carried out to:

- 1) work towards the development of an effective use pattern for B.t. against the spruce budworm;
- 2) further validate the reduced dosage/enhanced atomization concept of B.t. application; and
- 3) investigate the role of post spray weather on B.t. efficacy.

The unsatisfactory spray efficacy result with B.t. from the 1988 spruce budworm spray program in New Brunswick triggered a desire to have B.t. developed so that managing foresters in N.B. can have confidence in B.t. as a forest protection tool. It is essential that this take place, for in the near future B.t. may well be the only pest control product allowed for use against the spruce budworm. This is a double-edged sword for not only is there ambiguity with B.t. efficacy, it is more costly to use; which is the worst of both worlds (in a forest protection sense).

Work Plan:

A series of consultative meetings between representatives of Forest Protection Ltd., NBRPC, Forestry Canada, N.B. Dept. of Natural Resources, and Atlantic Weather and Environment Consultants resulted in the formulation of a testing protocol that called for treating 16,200 ha blocks (3200 ha): 4 at 15 BIU/ha-1X; 4 at 30 BIU/ha-1X; 4 at 15 BIU/ha-2X; and 4 at 30 BIU/ha-2X. The 30 BIU/ha-1X were scheduled as part of the "Good weather-Bad weather" segment of the experiments. These four spray blocks received additional sampling and investigations in the form of bioassay studies. Incorporated into the program plan was an evaluation of measurements of 'Dose acquisition' as suggested by Dr. Van Frankenhuyzen of the Forest Pest Management Institute.

The areas of responsibility were: project coordinator, E. G. Kettela; advisory services and spray deposit assessment, Dr. C. Wiesner (contract to RPC); weather monitoring and forecasting, R. B. Dickison (contract to AWEC); biological assessment and data analysis, E.G. Kettela (FCM) and V.C. Steel (contract); aerial application, Forest Protection Ltd.; supplies of dyed B.t., Chemagro Ltd.

To accommodate the requirements of this test series, some of the proposed operational treatment area was deleted to allow for positioning of test blocks in forest highly infested by spruce budworm and to eliminate contamination by drift from operational spraying. The B.t. insecticide selected for use was the aqueous based FUTURA XLV-HP. Its very high potency (33.3 BIU/L) fit the requirements of reduced dosage-enhanced atomization spraying. Two Cessna 188s (provided by FPL), equipped with 4 Micronair AU400s each, were used to apply the B.t. Treatment commenced on June 7 and finished on June 19.

Results:

Weather: Three strategically located base stations provided continuous data on wind velocity, temperature, relative humidity, rainfall, and solar radiation. The first six days were characterized by cool evenings and relatively cool days while the latter part of the test program experienced a gradual warming of weather. Six of the test blocks experienced rain within 24 hours of the treatment, and 13 of the 16 had rain within 48 hours. The "bad weather" blocks had cold, wet weather for the first 24 hours and the "good weather" blocks had warm, dry weather for the first 24 hours.

Spray Deposit: Average spray deposit ranged from 0.09 drops/needle to 1.5 drops/needle and appeared to be greatly influenced by air mass stability, with the highest deposits under near stable and neutral conditions. Average deposit was 0.6 drops/needle for 30 BIU/ha and 0.4 drops/needle for 15 BIU/ha. Spray deposit variability was the same for both applications.

Efficacy: Percent reduction in defoliation and survival (mortality) was quite variable, and was generally a function of deposit (Table 2.). Similar efficacy was measured between the 4th and late 5th instar. In spray blocks with very high populations of budworm defoliation was severe at the time of treatment (mid 5th instar). Further defoliation was prevented by the B.t. application. Overall, the two applications of B.t. provided incrementally more protection than one application and the 2X15 BIU blocks had the best overall results.

Impacts of Weather on Efficacy: Based on analysis of the bioassay and dose acquisition studies, cold/wet weather as experienced on the "bad weather" blocks reduced efficacy. In both sets of blocks (good and bad weather), spray deposit, fortuitously, was very similar. The bioassay data shows a steady decline in B.t. activity over 4 days. This is similar in both sets of blocks, indicating initial good contamination of foliage with B.t. but no apparent wash off by rain. The dose acquisition study shows a clear impact of the cold weather in the first 48 hours in the bad weather blocks, only 42 and 46% mortality compared to 85 and 92% in the good weather blocks. Spray blocks experiencing light rain in the first 24 hours or heavier rain after 36 hours were not affected adversely. It appears that the first 24 hours after treatment is the critical period for exposure of budworm B.t. and deposit appears to be the key factor in determining efficacy.

Conclusions:

- 1) The enhanced atomization of high potency B.t. is an effective application technology with FUTURA XLV-HP, sufficiently high deposits can be achieved with 15 BIU/ha to afford protection similar to 30 BIU/ha. Two applications of B.t. incrementally increased efficacy.
- 2) Very high populations of budworm cause severe defoliation to trees by the mid fifth instar of larval development. B.t. applications will afford protection to remaining foliage but efficacy is a function of spray deposit on foliage.
- 3) Cold, wet weather such as that experienced in the "bad weather" blocks impacts negatively on efficacy. Light rains have no apparent effect on efficacy but cold weather can limit feeding of budworm larvae, hence efficacy.
- 4) The dose acquisition assay is a unique and useful tool in experiments of this nature.

Develop of Pheromones for Control of Zeiraphera and spruce budworm

Cooperative trials with pheromones for control of Zeiraphera and spruce budworm were continued. This work is being done in cooperation with the N.B. Research and Productivity Council. Funding was through NB-FRAC and the Forestry Development Agreement. In addition ACOA, Dept. of Natural Resources and the Quebec Ministry of Resources and Energy contributed to spruce budworm pheromone study. In 1989, a two-component blend of Zeiraphera pheromone was tested against the main single pheromone component in a trapping study. This has identified where further research is needed. With spruce budworm pheromone research, this year's effort was spent field testing a whole tree and insect labelling method using rubidium chloride. This was necessary to develop a way of separating resident and non-resident egg masses. The results are very encouraging.

Laboratory Screening of Exotic parasites and related work

We received sufficient supplies of Tranosema carbonellum to carry out laboratory trials. Zeiraphera larvae were set up on white spruce foliage then exposed to mated female T. carbonellum. Oviposition took place within 30 minutes. However, no second generation of T. carbonellum have emerged as yet. If sufficient live material is available in 1990 further Laboratory screenings will be conducted.

Attempts to obtain Trichogramma from Zeiraphera ratzburgiana eggs was unsuccessful (second year). The idea was to obtain sufficient material for mass rearing and release. It is our aim to field test an inundative release with T. minatum when sufficient T.m. are available.

Development of Field testing of the Sergonair Nozzle

There was no opportunity to complete work with fenitrothion UULV sprays from TBM aircraft as the equipment was not available in time for efficacy testing.

TABLE 1. SUMMARY OF RESULTS OF EFFICACY TESTING OF B.T. PRODUCTS AGAINST THE SPRUCE BUDWORM ON BALSAM FIR FOLIAGE IN NEW BRUNSWICK, 1989

TREATMENT BLOCK NUMBER	VOL/HA L	SPRAY DEPOSIT DROPS/ NEEDLE	LARVA DEVELOPMENT INDEX ON SPRAY DATE	PRE-SPRAY* LARVAE/ BRANCH	ON SPRAY DAY	DEFOLIATION (Z) FINAL	EXPECTED	Z REDUCTION** IN DEFOLIATION
CIL-E2492 30 BIU/ha (K-13)	1.8	1.70	5.2	7.4	11	15	34	47
FUTURA-XLV 30 BIU/ha (K-14)	2.0	0.75	5.5	5.7	13	14	24	40
DIPEL-352 30 BIU/ha (S3-B)	0.8	3.72	5.1	2.9	5	6	15	60
DIPEL-352 15 BIU/ha (S3-A)	0.4	3.01	5.1	6.2	6	10	31	61
DIPEL 96AF 30 BIU/ha (B-39)	1.1	-	6.0	4.4	5	8	11	27

* Pre Spray Population Estimates - 48 hrs. before treatment.

** Z Reduction in defoliation calculated from expected and final defoliation estimates.

TABLE 2. SUMMARY OF SPRAY EFFICACY FOR SELECTED TEST BLOCKS
TREATED WITH FUTURA XLV-HP AGAINST SPRUCE BUDWORM
ON BALASH FIR, IN NEW BRUNSWICK, 1989

TREATMENT & BLOCK NO.	VOL/HA APPLICATION L	SPRAY DEPOSIT DROPS/NEEDLE APPLICATION		LARVA DEVELOPMENT INDEX		PRE-SPRAY LARVAE/ BRANCH	ON SPRAY DAY	% DEFOLIATION		% REDUCTION IN DEFOLIATION
		1st	2nd	1st	2nd			FINAL	EXPECTED	
15 BIU/ha 1 X (K-2)	0.4 0.4	0.28 1.49	- -	4.4 5.1	- -	6.1 13.2	10 25	14 28	28 39	42 41
30 BIU/ha 1 X (K-11)	0.8	1.08	-	5.3	-	13.6	53	63	85	12
15 BIU/ha 2 X (K-3)	0.4	0.32	0.10	4.3	5.3	13.7	15	19	85	62
(K-6)	0.4	0.68	0.27	4.2	4.8	12.6	10	15	65	65





FIGURE 1. Map of New Brunswick Showing general location of Test Sites, 1989



**Progress Report on Residual Efficacy of Dipel Formulations
Sprayed Aerially Against Spruce Budworm
at Bathurst, N.B., During 1988 & 1989**

P. C. Nigam and S. E. Holmes

INTRODUCTION

This study was started in 1988 with Dipel 12L, a concentrated oil formulation of B. t. containing 25.4 BIU/litre. A further concentrated formulation, Dipel 16L containing 33.8 BIU/litre, was tested in 1989 and effectiveness was compared with Dipel 12L. Both formulations were developed by Abbott Laboratories. Results of the 1988 study were reported during Sixteen Annual Forest Pest Control Forum.

Experiments were conducted in cooperation with Mr. E.G. Kettela, Forestry Canada-Maritimes, Forest Protection Limited, Research and Productivity Council and Abbott Laboratories under the auspices of the New Brunswick Spray Efficacy Research Group (NB SERG).

The objectives of this year's study were to determine the (i) residual efficacy of Dipel 16L, aerially atomized by Micronair AU4000, @ 15 and 30 BIU/ha and to compare the results with Dipel 12L sprayed similarly in 1988, (ii) effect of post-spray weather parameters on deterioration of residual toxicity of Dipel 16L and to compare with 1988 weather effects on Dipel 12L. A brief summary of methods and materials, and results are presented for this report.

METHODS AND MATERIAL

The experiments were conducted at Bathurst, N.B. Three plots of approximately 200 hectares were selected for two treatment and a control in 1988 and two treatment and two control plots in 1989 of similar size were selected. The treatment plots were sprayed with 15 and 30 BIU/ha of Dipel 12L and Dipel 16L using two Cessna 188's equipped with four Micronair AU400's on each aircraft. The Micronairs were rotated at maximum speed. Dipel 12L was sprayed @ 0.55 litre/ha and 1.1 litre/ha for 15 and 30 BIU respectively in 1988. Dipel 16L was sprayed at 0.4 litre/ha and twice at 0.4 litre/ha for 15 and 30 BIU respectively.

The Dipel formulations were dyed with 1% Day Glo Orange dye by weight for deposit assessment. The deposit assessment was performed on various components of larval microhabitat and artificial surfaces. Only deposit assessments on needles are given for this report. Deposits on new (current) and old needles were measured using three different magnifications (30X, 60X and 100X) during the last two years.

Weather parameters were recorded on a micrologger. Information on canopy level weather was collected using sensors on a 10 meter meteorological tower. Thermocouple (temperature) and leaf wetness sensors were located on host tree branches for collection of data near larval microhabitats.

Foliage samples were collected for (i) bioassay of residues (ii) deposits on needles (iii) droplets on webbings and (iv) budworm behaviour and droplet-interaction.

Pre-spray samples were collected at least 48 hours before spraying and post-spray samples were collected on spray day (0 day), 1 day, 3 day and 5 day after spraying. Residue bioassay samples were kept in paper bags. Twenty-five to fifty current year buds were collected from one branch; if sufficient shoots were not available then a second branch was used. All samples were kept cool and in high humidity in styrofoam coolers in the field and then stored in walk-in-growth-chambers at 0 - 2°C. Bioassay of foliage for residual efficacy of 15 and 30 BIU/ha of Dipel sprays was carried out using laboratory reared IV instar larval in 10 cm clear plastic dishes. Approximately 10 buds were supplied per dish and 10 larvae per dish were used. In 1988 a total of 120 larvae were used for each observation period, while in 1989 the number of larvae was doubled to 240 for each observation. The mortality counts were taken after 1, 3, 6 and 9 days of releasing the larvae on foliage, at pupation, and at adult emergence. Results of nine day larval mortality counts are presented in this report.

RESEARCH AND DISCUSSION

Bioassay results were documented for 1988 and 1989, along with mean needle deposit data measured at three different magnifications. It is clear that Dipel 16L in 1989 has given residual toxicity as compared to Dipel 12L in 1988. There is no difference from the practical point of view between the 15 and 30 BIU applications of both formulations. The difference between the 1989 and 1988 results seem to be due to higher mean deposit/needle, and due to the higher concentration of B.t. in Dipel 16L which is reflected in higher and longer lasting mortality. The effect of high deposit seems to play the dominant role in 1989 mortality; sufficient residual toxicity has lasted up to 5 days after spraying. Lower volume (0.4 litre/ha) improved the deposit because a higher number of smaller droplets were produced by the Micronairs which emitted the low volume at high rotation speed. This was also noticed in 1988 when 0.55 litre/ha and 1.1 litre/ha were applied; there was better deposit at the lower application rate.

In 1989 rain started approximately 24 hours after spraying and a total of 9.9 mm fell within the next 12 hours i.e., by 1800 hours on June 16, 1989. The 1 day samples were collected while it was raining. Approximately 10.4 mm rain fell before the 3 day samples were taken for bioassay. It appears rain had no drastic effect on the residual efficacy of Dipel 12L was low on the spray day and 1 day samples, and seems to be more a function of lower deposit than of the effects of weather elements.

Temperature, relative humidity and radiation were also investigated. They do not seem to affect the residual toxicity too much. Initial deposit affects residual toxicity significantly; with higher deposits the residual effect lasts longer. Weather may modify toxicity but has not played a dominant role under these experimental conditions. Dipel 16L has improved residual efficacy of B. t., and further development and registration of this formulation is recommended.



HERBICIDES

A Summary of the Operational Herbicide Research Being

Conducted by FPMI in New Brunswick

Doug Pitt & Dean Thompson

FPMI conducts operational conifer release and site preparation trials that are aimed at the investigation of new and improved uses of herbicide products, new herbicide formulations, and new application technologies. Herbicide efficacy, crop tolerance and growth response, and environmental fate data are generated to address operational silvicultural questions. The following paragraphs briefly outline 1989 research that FPMI undertook in New Brunswick in support of this mandate.

New Operational Herbicide Research:

This past summer, FPMI worked cooperatively with J. D. Irving Limited, Forestry Canada-Maritimes Region, Chipman, DowElanco and Company, and Monsanto Canada to establish a comparative brush-control trial in New Brunswick. The research is aimed at the identification of optimal rates and products for the control of problem weed species. The study is designed to demonstrate and compare RELEASE (formerly GARLON 4), TOUCHDOWN, VISION, MON14420, and manual control as broad-spectrum, brush-control tools in both conifer release and site preparation roles. In addition, environmental fate data, required for registration of new products, will be generated.

A study area was chosen on J.D. Irving freehold land 40 km north of Fredericton, New Brunswick. The area had been full-tree logged during the fall and winter of 1986/87 and was, at the time of treatment, dominated by hardwood samplings and stump sprouts. Sugar maple is the predominant species on the site, accounting for 43% of total hardwood density (40,000 stems/ha) and 45% of total crown area (5,700 m²/ha). Red maple, striped maple, yellow birch, beaked hazel, white ash, mountain maple, and beech comprise the remaining hardwood cover on the site.

In August 1987, the site was divided into sixty-six 40m x 25m plots with 10-m vegetation buffers between each. Within the center of each plot, twelve subsample locations were established at 2.1-m intervals in a cross pattern, the center of each marking the future planting location of a crop tree and focal point for future planting location of a crop tree and container stock was planted in 4 of the 12 subsamples in each plot. These trees were allowed to become established prior to treatment and will provide 'release' data for the study. A further 24 trees (of similar stock) were planted in each plot immediately after

treatment, in order to provide future 'site prep' and growth response data.

Pre-treatment vegetation sampling took place in mid August of 1989. Brush data included measurements of stem density, crown area, crown volume, stem diameter, and basal area, by species. Herbaceous species were evaluated by height and percent cover. Crop data consisted of measurements of seedling height and stem and crown diameter, as well as evaluations of health.

Treatments consisted of 5 rates of each chemical, one manual control treatment, and an untreated check plot. Each treatment was replicated 3 times in a randomized complete block design. Specific rates (kg ai/ha) tested were:

	1	2	3	4	5
Release	0.400	1.260	2.120	2.980	3.480
Vision	0.250	0.722	1.193	1.665	2.136
Mon14420	0.250	0.722	1.193	1.665	2.136
Touchdown	0.232	0.669	1.106	1.543	1.980

Chemical treatments were applied during the morning spray sessions of September 4, 5, and 6, 1989. Three backpack CO₂ sprayers (R & D Sprayers, Inc., Model 4F), each equipped with a FLOODJET 1/4KLC-9 nozzle, were used for the applications. With a release height of 4.5m, these sprayers offered a swath width of 9.5m and a droplet VMD of 1089 μ m. Total volume of all applications was 109 l/ha.

A comprehensive evaluation of chemical deposit and environmental fate was conducted. This included, for each chemical,

- a) verification of each tank-mix concentration,
- b) assessment of initial on target deposit on both artificial and natural surfaces (glass-fiber filter paper and sugar maple foliage, respectively),
- c) determination of dissipation kinetics in foliage, thatch, organic and mineral soils, and
- d) determination of chemical residue transport in association with leaf fall.

Sampling of sugar maple foliage and leaf litter were completed shortly after application, while sampling of soils and thatch continued through until freeze-up and will resume in the spring, through to August. Analysis of tank mix concentrations and initial deposit on artificial collectors have been completed. Residue analysis in foliage, thatch, and soil

samples is currently ongoing.

Manual treatments will be conducted with a Husqvarna brush saw this coming June, after full leaf expansion. Weed and crop measurements will be repeated in August.

A comprehensive status report, containing pre-treatment weed and crop data and available environmental fate data, will be prepared prior to next year's field season. Copies will be available upon request.

Ongoing Operational Herbicide Research:

During the summer of 1988, FPMI worked cooperatively with the New Brunswick Department of Natural Resources and Energy and Forestry Canada-Maritimes Region, to establish a trial designated to develop an improved-use strategy for VISION (glyphosate). The objectives and methodology of this study were outlined in the 1988 EMOFCO report. This past July, all plots were located and first-season herbicide efficacy, crop tolerance, and crop growth response data were collected. Data analysis is currently being completed reports should be written prior to this field season.



ENVIRONMENTAL MONITORING

Contamination of ponds by fenitrothion during forest spraying

W. Ernst, G. Julien and P. Hennigar

Fenitrothion (0,0-dimethyl 0-4-nitro-*m*-tolyl phosphorothioate) has been the chemical of choice in spray programs directed at forest defoliators in New Brunswick, Canada for over twenty years. Contamination of watercourses by pesticide is an unavoidable aspect of large block spraying. A recent review of the environmental effects of forestry fenitrothion use, indicated that although most watercourse contamination does not cause major biological impact, certain water bodies may be of higher risk (Fairchild *et al.* 1989). Those are small, still water bodies which are shallow and have reduced forest canopy. Such water bodies are of the type that are most difficult to detect from the air and therefore to protect with buffer zones. There is also evidence which indicates that in ponds with low pH, biological impact may be serious. Studies have indicated that at simulated operational dosage rates, aquatic invertebrate impacts in bog ponds are of such magnitude as to substantially alter energy flows through those ecosystems (Fairchild 1990). It was necessary to determine the contamination of small ponds by forestry insecticides during operational spray programs in order to assess the exposure to lentic biological systems.

METHODS

Six ponds were selected within operational spray blocks of the 1989 spruce budworm spray program in New Brunswick. The pond selection criteria were: small size (less than 0.5 ha); easy accessibility; and central location within the spray block. All blocks were scheduled to be treated twice, approximately 5 to 10 days apart. The intent was to monitor surface deposit and initial surface water contamination after each spray; all ponds were not sampled after each spray but ten discrete deposit events were sampled. All blocks were sprayed with a water solution containing 11.0% fenitrothion, 1.5% Dowanol TPM, 1.5% Atlox 3409F and 86.0% water. The total volume of spray solution emitted was 1.46 L/ha, for a nominal application rate of 210 g active ingredient/ha. Spray was applied by Gruman TBM Avenger aircraft equipped with Tee Jet 11010 nozzles. Aircraft height was approximately 25 m above the tree canopy and speed was about 280 km/h.

Deposit was collected on 20 cm diameter cellulose filter papers which were clipped to stainless steel plates supported 30 cm above the pond surface by rods attached to styrofoam floats. Six such samplers were distributed over the surface of each pond. Within 15 min of the treatment, filters were retrieved and immersed in 100 mL of hexane until analysis.

One-litre surface water samples (0-1 cm) were also obtained prior to and 15 min post-spray at the same locations as deposit collectors by immersing a 1-L narrow necked bottle so that one half of the mouth was submerged. In addition, replicate water samples were obtained from each pond outflow at various times, (100 mL hexane with vigorous shaking for 5 min) was begun within one hour of spray. Final extractions were subsequently performed within two weeks of collection and immediately prior to gas chromatographic analysis using flame photometric detection (Department of Environment 1979).

Where possible, foliage samples from balsam fir trees adjacent to the ponds were also collected before and immediately after spray at approximately three-quarters crown height. Sufficient foliage was removed from collected branches to make up a 50-g sample which was immersed in 100 mL of hexane and maintained in a frozen state until analysis.

Measurements were also made of: windspeed and direction at 10 m height (Gill Anemometer Bivane); air and water temperature; and water pH. Pond size, depth and outflow rate were estimated and surrounding vegetation and topography recorded.

RESULTS

Observations from the ground at the time of spraying indicated that the spray aircraft did not stop spraying when approaching any of the ponds and all ponds appeared to receive a direct application. That is normal spray procedure in the province of New Brunswick where spray buffer zones are not required for small water bodies (i.e. non-designated rivers and lentic bodies less than 40 ha in size). Ground observation and review of spray team flight reports indicated that there were perceived problems in flight line alignment or other delivery aspects in 30% of the observed sprays in the immediate location of the pond. Such events may contribute to variable deposit.

The canopy around all ponds was open with no overtopping vegetation that would intercept sprays, preventing direct deposit. Riparian vegetation consisted of short (1-2 m) willow and alder that had no foliage at the time of application. The width of that vegetation zone varied from 2-30 m and was adjoined by mature conifers which were 20-25 m in height. Topography surrounding the ponds was generally flat, except for ponds 4 and 5 which were situated at the bottom of a steep valley. Characteristics of the sampled ponds and the conditions at time of spray are contained in Table 1.

Measured deposit of fenitrothion on filter paper after spray ranged from 24.3 to 0.7 mg/m². Mean deposits (Table 2) ranged from 17.6 ± 4.6 mg/m² on Pond 1 after the first spray event to 1.2 ± 0.2 mg/m² on Pond 1 after the second spray event. The highest mean deposit

TABLE 1 Characteristics of sampled ponds and conditions at time of spray

Pond #	Spray event	Pond dimensions (m)	Depth (m)	Outflow (L/S)	Water temp. (°C)	Air temp. (°C)	pH	Wind speed (m/s)	Wind direction (°)	Spray time	Spray deviation
1	1	25 x 25	1.0	.63-.95	4.5	-	6.6	.300	200	06.31	None
2	1	40 x 20	1.0	.63-.95	4.5	-	6.6	.300	200	06.31	None
3	1	50 x 30	0.5	<.63	-	-	6.0	.511	-	18.10	None
4	1	20 x 30	0.75	6.3	-	-	6.0	.511	10	19.27	Booms off on one plane
5	1	30 x 50	0.57	6.3	-	-	6.0	.511	10	19.27	Booms off on one plane
6	2	80 x 15	1.0	.63-.95	-	7.0	6.6	1.256	90	07.36	None
2	1	40 x 20	1.5	.63	14.0	19.0	6.6	no wind	-	08.19	Plane off flight time
4	2	20 x 30	0.75	6.3	-	-	6.0	3.81	-	06.02	None
5	2	30 x 50	0.5	6.3	-	-	6.0	3.81	-	06.02	Plane off flight time

represents 84% of the emitted application rate, however, total mean deposit was approximately 32% of the emitted application rate.

Table 2 Fenitrothion deposit on flat collectors and immediate pond surface water concentrations after forest spraying

Pond	Spray Event	Mean deposit - mg/m ² ($\bar{X}$ S.D.)	Mean surface water concentration -mg/L ($\bar{X}$ + S.S.D.)
1	1	17.6 $\pm$ 4.6	0.8 $\pm$ 0.7
2	1	12.8 $\pm$ 3.0	1.5 $\pm$ 0.5
3	1	3.3 $\pm$ 0.5	0.04 $\pm$ 0.02
4	1	4.2 $\pm$ 0.8	0.2 $\pm$ 0.09
5	1	6.6 $\pm$ 0.4	0.09 $\pm$ 0.1
6	1	4.2 $\pm$ 2.9	0.2 $\pm$ 0.1
1	2	1.2 $\pm$ 0.2	0.02 $\pm$ 0.01
2	2	5.8 $\pm$ 1.2	0.3 $\pm$ 0.1
4	2	5.9 $\pm$ 0.8	0.3 $\pm$ 0.3
5	2	4.8 $\pm$ 0.7	0.04 $\pm$ 0.04

The pre-spray surface water concentration of fenitrothion ranged from 0.0011 mg/L to <0.00005 mg/L (the detection limit for the analysis). Surface water concentrations of fenitrothion after spraying, ranged from 2.5 mg/L to 0.006 mg/L. Mean surface water concentrations ranged from 1.5 $\pm$ 0.5 mg/L on Pond 2 after the first spray event to 0.04 $\pm$ 0.04 mg/L on Pond 5 after the second spray event.

There are no obvious influences of meteorological conditions at the time of spray, topography, or perceived application anomalies on deposit. Concentrations of fenitrothion in outflow water were much smaller than those in pond surface water (Table 3). Mean outflow concentrations ranged from 26.0 ug/L to 0.2 ug/L. No consistent pattern in outflow concentration changes with time was evident, however, in five of the seven spray events monitored, concentrations increased or remained relatively stable with time up to 2 h after spray.

Residues of fenitrothion in conifer foliage after the first spray event had a mean value of 3.0 $\pm$ 1.7 ug/g (N = 9). Residues in foliage after the second spray event were similar with a mean of 2.3 $\pm$ 1.5 ug/g (N = 9). Two samples obtained prior to the first spray event contained 0.57 and 0.51 ug/g fenitrothion while those obtained prior to second spray (N = 6) contained a mean of 0.4 $\pm$ 0.2 ug/g.

Table 3 Fenitrothion concentrations in pond outflow at various times after spray

Pond	Spray event	Mean surface concentration (ug/L)	Outflow concentration* (ug/L)			
			post-spray 15 Min.	30 Min.	1h	2h
3	1	40	1.7	0.8	2.2	3.4
5	1	100	24.0	15.0	26.0	23.0
6	1	200	2.6	2.8	2.8	3.0
1	2	20	0.2	0.2	0.2	0.3
2	2	300	2.9	5.0	18.0	19.0
4	2	300	12.0	N/A	N/A	N/A
5	2	40	13.0	12.0	8.3	8.0

* Means of two samples.

DISCUSSION

Although the deposit on filter papers was highly variable which may be related to observed delivery anomalies, mean deposit (31.6% of emitted active ingredient) was comparable to that reported by Armstrong (1977) to be typical of operational forestry sprays (25-30% of emitted dosage rate). Also deposit on sampled foliage was similar to that previously recorded for forest spraying (Pierce and Ernst 1988).

Surface water concentrations of fenitrothion reported here are greater than those which have been previously observed in lentic water after operational spraying. There have been several reports of peak lentic water concentrations which range between 0.2 mg/L and 1.1 mg/L (Mamarbachi *et al.* 1985, Moody *et al.* 1978, and Morin *et al.* 1986), however, most studies have reported peak concentrations of less than 0.06 mg/L (Ernst *et al.* 1980, Kingsbury 1977, Holmes *et al.* 1984). Those studies however, have measured concentrations in large bodies of water such as lakes, many of which may have been protected by buffer zones or at least not directly oversprayed. Concentrations of forestry insecticides are greater in lentic than in lotic systems immediately after spraying (Fairchild *et al.* 1989), and in one study, residue concentrations measured in a pond were five times those measured in a stream immediately after forestry spraying with fenitrothion (Hiramatsu *et al.* 1990).

The maximum mean surface water concentrations observed are within the range of fenitrothion 96-h LC 50's (0.7 - 1.9 mg/L) for salmonid fish (Doe *et al.* 1988, Sanders *et al.*

1983, Wells *et al.* 1979) and that observed to cause decreased survivability and embryo deformity of medaka (*Oryzias latipes*) (Hiraoka *et al.* 1990). It must be recognized, however, that the maximum surface water concentrations are rapidly attenuated due to dilution and degradation (Kingsbury 1977, Maguire and Hale 1980) and are not directly comparable to concentrations of fenitrothion used to develop laboratory toxicity values.

Total arthropod benthos density depletions of approximately 50% (primarily Chironomidae and Ceratopogonidae) have been reported in bog ponds which had immediate surface post-spray concentrations of 42 - 81 ug/L fenitrothion in an experimental ground application (Fairchild 1990). While the effect that low water pH has on modifying the magnitude of those impacts has not been determined, the residue concentrations in this study of 10 to 20 times those of Fairchild (1990), indicate that the impact of forestry use of fenitrothion on benthic invertebrates in small pond may be substantial and should be determined.

Residue concentrations in outflow water are representative of well-mixed water column concentrations and were much lower than those in the ponds they drained. In some cases however, they exceeded the 20 ug/L threshold for lotic benthic invertebrate impact calculated by Ahern and Leclerc (1981). Furthermore, the pattern of residue concentration changes with time in outflow water indicate that the duration of elevated residue concentrations may be somewhat longer than that normally encountered in lotic systems.

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REGULATORY ACTIVITIES

Operational Forest Spray Monitoring

W. A. Sexsmith

The New Brunswick Department of the Environment has the mandate to regulate pesticide application in the Province, including both the spruce budworm spray program and the forest herbicide spray program (Table 1). The total number of man hours spent monitoring these programs for permit compliance was 100 and 110, with 2 and 0 incidents (complaints, etc.), respectively, investigated. One spill or jettisoned load occurred, relating to the forest herbicide spray program.

Setbacks or buffer zones, have been used as a regulatory tool over the years in New Brunswick as a means to protect designated sensitive areas from impact of spray operations. Setbacks that were in place for 1989 for the forest insecticide spray program are indicated in Table 2 and for the forest herbicide spray program, Table 3.

Setbacks for research applications, not indicated in the tables, were 8 km from human habitation for a new (unregistered) active ingredient, and 3.2 km from human habitation for a previously registered active ingredient. Environmental setbacks are developed on a product-specific basis.

These buffer zones, although there have been few changes in the past few years, are not meant to be static but are such that they may change as the information available changes.

TABLE 1

1989 Pesticide Use in Forestry
in New Brunswick (aerial)

<u>Agency</u>	<u>Product</u>	<u>Pest</u>	<u>Hectares</u>	<u>Rate/ha</u>
<u>Insecticides</u>				
Forest Protection Ltd.	fenitrothion	budworm	466,700	2 x 210g
			5,300	1 x 210g
	<u>Bacillus thuringiensis</u>		8,800	1 x 15 BIU
			31,200	1 x 30 BIU
			49,900	2 x 15 BIU
			15,000	2 x 30 BIU
J. D. Irving Ltd.	fenitrothion		34,000	2 x 210g
	Futura XLV		2,078	2 x 15BIU
Forestry Canada (research)	Futura-HP		3,200	15 + 30BIU
	Futura - 0		800	15 + 30BIU
	Dipel 16L		800	15 + 30BIU
	Dipel 96AF		800	15 + 30BIU
	Foray 48B		200	30BIU
	CIL E492		200	30BIU

1989 Pesticide Use in Forestry
in New Brunswick (aerial)

<u>Agency</u>	<u>Product</u>	<u>Pest</u>	<u>Hectares</u>	<u>Rate/ha</u>
<u>Herbicides</u>				
Department of Natural Resources and Energy	glyphosate	hardwoods and herbaceous vegetation	16,876	2.1 - 4.9L
	triclopyr (research)		291	2.1 - 4.9L
J.D. Irving Ltd.	glyphosate		14,076	3.7 - 4.2L
	triclopyr (research)		300	3.7 - 4.9L
	glyphosate- water-soluble (research)		25	3.7 lbs.
Fraser Inc.	glyphosate		8,845	3.5 - 4.5L
	triclopyr (research)		196	3.5 - 4.5L
	triclopyr and glyphosate 1:1 (research)		56	2.25L of each product
Canadian International Paper	glyphosate		916	4.9L/ha

TABLE 2(a)

INDUSTRIAL BUDWORM PROGRAM - TBM & 4 ENGINE AIRCRAFT

	FEM	BT
Habitation	1.6Km	1.6Km
Lakes >40 ha	400 M	0
Designated Major Rivers	400 M	0
Ecological Reserves	400 M	400 M
Municipal Water (Pt. of Extraction)	3.2 Km	3.2Km

FEM - Fenitrothion

BT - Bacillus Thuringiensis

TABLE 2(b)

SSP BUDWORM PROGRAM (SMALL SPRAY PLANES)

	FEM	BT
Habitation	300 M	155 M
Open Surface Water	65 M	0
Ecological Reserves	65 M	65 M
Municipal Water (Pt. of extraction)	3.2 Km	3.2 Km

FEM - Fenitrothion

BT - Bacillus Thuringiensis

TABLE 3

HERBICIDE PROGRAM - AERIAL

	GPS
Habitation	155 M
Surface water	65 M
Municipal Water (Pt. of extraction)	3.2 Km
Property boundaries	50 M

GPS - Glyphosate

MONITORING IN OTHER JURISDICTIONS

Environmental Monitoring of Pesticide Spraying in Quebec Public Forests in 1989

S. Dellisle, J. Legris, J. Cabana and P-M. Marotte

INTRODUCTION

The Service des études environnementales (SEE) has a mandate to evaluate the impact of pesticide spraying in forests. It is also responsible for ensuring that the products are safely used as regards human health or the environment.

Every year, the SEE carries out a quality control and environmental monitoring program of the insecticides sprayed by the ministère de l'Énergie et des Ressources (MER) to control forest pests. It also monitors the herbicides used for upkeeping plantations and preparing ground. In conducting these studies, it takes samples of various environmental components or organisms which have been exposed to spraying.

This paper summarizes the various monitoring activities carried out in 1989. It also presents some preliminary results, the final analysis of which will be the subject of further reports.

A. Insecticide Spraying Against the Spruce Budworm

For the past three years, the MER has used only BTK-based (Bacillus thuringiensis var kurstaki) biological insecticides to control spruce budworm (Choristoneura fumiferana Clem.). Several studies have shown that this bacterium is innocuous to man, wildlife and the environment in general. However, insecticides contain spores that may persist, accumulate and possibly reproduce under suitable conditions. The SEE has therefore decided to monitor spraying in order to assess the short-and long-term persistence of these spores. An annual sampling program in various environmental surroundings has been worked out for this purpose. The SEE is also responsible for controlling the quality of BT formulations.

In 1989, the MER operational spraying program covered 164,216 hectares of forests. Dipel 132 was sprayed over 76% of the area and Dipel 176 over the remaining area. Most of the zone was treated at the rate of 30 MUI/ha. However, 34,579 hectares had two applications of BT for a total of 60 MUI/ha.

Details concerning experimental treatments will be exposed later.

1. Monitoring Operational Products

a) Persistence of Thuricide 48LV in Soil

In 1985, the MER undertook a study of the long-term persistence of BT in the soil of areas treated with Thuricide 48LV. Initially 29 sampling sites were established and sampled. Since then, several sites have had to be abandoned for various reasons. In 1989, the SEE was able to sample 12 sites. The aim of this project was to evaluate the presence of BT spores in soil four years after treatment and especially the increase of concentrations in the mineral layer. Twenty-four samples were analyzed during the project.

b) Persistence of Dipel 132 in Soil

In 1987, the MER started to study the short-and long-term behaviour of Dipel 132 in forest soil. This oil-based product was used for the first time in Quebec for operational treatment spraying. The study aimed at evaluating the presence of BT spores a few days after treatment and their persistence one year later. For this purpose, samples were collected after the 1987 and 1988 sprayings.

In the spring of 1989, the SEE samples 12 soil sites to evaluate BT concentrations one year after spraying in areas treated during two consecutive years. Twenty-four organic and mineral soil samples were collected.

c) Persistence of Dipel 132 in Lakes

In 1989, the SEE carried on a two-year old study on the behaviour of Dipel 132 in the water and sediments of lakes. This year, four lakes located inside areas treated in 1987 were sampled to assess BT persistence two years after spraying. Sampling was also done in four other lakes that were exposed to both 1987 and 1988 sprayings. The latter project aimed at evaluating BT concentrations and possible accumulation one year after a second consecutive year of treatment. A total of 40 sediment samples and 24 water samples were analyzed during the study.

d) Evaluating BT Concentrations in Soil Following a Double Application

In 1989, some forest areas with high larval population received two applications of Dipel 132 or 176 spaced out over a few days. Both applications were done with the same product at the rate of 30 MUI/ha each. Twenty soil sites were established and sampled to evaluate the concentrations of BT viable spores after spraying. Samples were collected before the treatment and one to three days after each application. The last samples were taken three months later. This sampling and the one preceding the spraying included organic and mineral soil collections. In the days following the spraying only the organic layer was sampled. A total of 80 organic soil samples and 40 mineral soil samples were collected.

Experimental treatments in forests are essential for the registration process of new insecticides. The MER is currently participating in certain projects aimed at measuring the effectiveness of products and studying the behaviour of spores in the environment. In 1988, two products were subjected to environmental monitoring. These are E-492 by CIL and Condor by Ecogen. This study ended in 1989 with the assessment of long-term persistence.

The 1989 experimental program enable the MER to test seven new biological products over a total area of 504 hectares. The SEE monitored only one insecticide known as Foray by Novo Inc.

a) E-492 (CIL)

This formulation was sprayed in 1988 by aircraft at the rate of 30 MUI/ha. The SEE elaborated a sampling program in collaboration with CIL. The objective of the program was to study the behaviour of E-492 in the days and months following the treatment. Samples were taken in one stream and 16 soil sites. In 1989, the SEE sampled the same sites to verify the presence of BT after one year. Thirty-two organic and mineral soil samples and one water sample were collected.

b) Condor AF (Ecogen)

In September 1988, the MER carried out a study on the behaviour of Condor AF in forest soil after a manual application. Eight soil sites were treated with this product by means of a pneumatic sprayer. Eight other sites were treated simultaneously with Dipel 132 to compare the behaviour of both products under similar conditions. Samples were taken before treatment, just after treatment and three months later. In 1989, samples were collected at the 16 sites to assess the persistence of BT after a 19-month period. Twenty-two organic and mineral soil samples were taken during the project.

c) Foray 48B (Novo)

This water-based formulation was sprayed in 1989 by a Piper Pawnee single-engined aircraft over two areas of 36 hectares. Each area received a single application of 30 MUI/ha in a volume of 2.37 l/ha. After the treatments, soil was sampled in both areas in order to evaluate BT concentrations. Eight soil sites were sampled in each area prior to spraying. Other samples were taken one to three days and three months after treatment. Forty-eight organic soil samples and 32 mineral soil samples were collected. BT concentrations will be evaluated again after a 12-month period in the spring of 1990.

B. HERBICIDES SPRAYING ON PUBLIC LAND

To validate and complete our knowledge of the behaviour of the herbicides used by the MER in the forest environment, the SEE has continued to monitor glyphosate (Vision) and

hexazinone (Velpar) in 1989. A total of 5,948 hectares received ground applications of herbicides to upkeep plantations and prepare lands to be reforested. Most treatments (4,376 ha) were done with glyphosate, to release coniferous plantations from competing vegetation.

1. Glyphosate

Nine samples were taken in lotic water, to validate the data collected in previous monitoring programs and verify the quality of spraying. Most of these samples were taken near the treated areas within two days following the first shower to occur in the area. Fourteen sediment samples were collected with the same approach within a period of one month after spraying. Twenty-four other sediment samples enabled the SEE to complete some studies initiated in 1987 and 1988. Ten soil samples were also taken to conclude the monitoring of some accidental dumping sites.

The amount of glyphosate residues in raspberries was measured in two sampling sites. Samples were collected prior to treatment, 3 hours, 1, 2, 3, 4, 5, 6, 7 and 14 days after treatment. This study aimed at evaluating the effect of precipitation on the behaviour of glyphosate in fruits. Fifteen other fruit samples (raspberries and blueberries) were taken during the first week following treatment to evaluate the maximum residual concentration. The same samples will be used to verify the effect of rain on the leaching of glyphosate on fruits. For this purpose, a part of each sample will be washed before analysis with a known amount of water.

Spray drift was evaluated in four different areas during ground spraying with a BoomjetTM type sprayer (OC 20 nozzle). Twelve series of aluminum foils (Chromatographic analysis) were placed perpendicular to spray lines, to measure drift at 10, 25, 50 and 100 metres from the treated area. Note that the last three distances correspond to the width of the buffer zones given to sensitive areas and required by the MER.

2. Hexazinone

The hexazinone monitoring program was somewhat more limited than that carried out for glyphosate, since hexazinone is not widely used in Quebec and that several spraying techniques are still on trial. Nevertheless, three water samples and seven sediment samples were collected in lotic water.

Residual concentrations in soil were evaluated in an area of ground preparation treated with Boomjet sprayers. This type of sprayer gives a more uniform application over all the area. Soil was sampled to the depths of 1-10 and 10-20 cm after 10 days, 2 weeks, 1, 2, 3, and 5 months.

A few raspberry and blueberry samples were also collected in areas treated with this herbicide.

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